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SCIENTIFIC INVESTIGATIONS

Early time-restricted eating advances sleep in late sleepers: a pilot randomized controlled trial

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Study Objectives: This study evaluated the effects of early time-restricted eating (eTRE) on shifting the timing of sleep among late sleepers. Primary outcomes included actigraphy- and sleep diary–derived sleep onset, midsleep phase, and wake time with total sleep time as a secondary outcome.

Methods: Fifteen healthy adults with habitual late sleep timing were randomized to receive either eTRE or sleep and nutrition hygiene (control) via a single 30-minute synchronous video session. Participants completed an initial 1-week baseline phase followed by a 2-week intervention phase. Measures included continuous sleep monitoring and sleep and nutrition diaries.

Results: Linear mixed-effects modeling demonstrated that eTRE significantly advanced sleep timing compared with controls. Self-reported sleep onset (56.1 [95% confidence interval: 20.5, 91.7] minutes), midpoint (19.5 [7.2, 31.9] minutes), and offset (42.2 [2.9, 81.5] minutes) each moved earlier in eTRE as compared with controls. Similarly, objectively determined sleep onset (66.5 [29.6, 103.4] minutes), midpoint (21.9 [9.1, 34.7] minutes), and offset (39.3 [1.3, 77.3] minutes) each moved earlier in eTRE as compared with controls. Total sleep time showed a nonsignificant increase in the eTRE group as compared with controls.

Conclusions: Late sleepers who were instructed in a single session about eTRE significantly advanced their sleep timing, especially sleep onset. eTRE shows potential as a clinical strategy for advancing sleep timing in late sleepers.

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Keywords: early time-restricted eating, sleep, treatment

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Early time-restricted eating is a newer technique that is commonly used to adjust the behavior and timing of the food-entrainable oscillator. We wished to determine whether this technique could also aid in the adjustment of sleep timing.

Study Impact: We found that, with only a single, 30-minute intervention, we were able to move the timing of sleep to an earlier hour in late sleepers. While a small pilot study, our findings indicate the potential clinical effectiveness of this intervention in individuals with late sleep.

INTRODUCTION

The timing of sleep is influenced by several factors, including internal preference ("chronotype"), which is driven by the central circadian pacemaker in the suprachiasmatic nucleus, and social constraints (eg, work, school, family). Late bedtimes are often associated with poor health outcomes, including depression,[1] suicidality,[2] impaired cognitive performance,[3] insulin resistance, obesity, and diabetes[4,5] and may lead to short sleep duration due to fixed, early-morning responsibilities. Individuals who prefer a later bedtime may find it difficult to "try" to go to sleep earlier, as the suprachiasmatic nucleus provides a strong wake signal in the hours just before normal bedtime.[6] Consistent use of morning light, and avoidance of evening light, can help some individuals go to sleep earlier by shifting the timing of the suprachiasmatic nucleus to an earlier hour.[7] However, given the ubiquity of device use at night (ie, smartphones, tablets, etc[8,9]), absolute avoidance of light at night is problematic. One potential alternative mechanism to move sleep timing earlier is to engender changes in the food-entrainable oscillator.

The food-entrainable oscillator is a powerful secondary clock in mammals capable of synchronizing peripheral tissues, entraining body temperature, and helping to adjust sleep and wake independently of light–dark rhythms.[10] Preliminary work has shown that leveraging the food-entrainable oscillator using early time-restricted eating (eTRE; eg, eating only between 8 AM to 4 PM) may rapidly reset peripheral clocks and reduce jet lag symptoms, including disruptions to sleep, mood, and concentration.[11] This method consists of 2 primary components: a fast of longer than 16 hours followed by a large meal in the targeted "morning." Synchronizing peripheral clocks using time-restricted eating also appears to optimize metabolic health (eg, lowering hemoglobin A1c, reducing insulin response), independently of weight loss, but only when done early as time-restricted eating beginning at midday (eg, 12 PM to 8 PM) has produced mixed results.[12,13] Based on these emerging data, strategic fasting

(ie, eTRE) could be a potentially helpful countermeasure to circadian desynchrony and its negative sequelae.

Whereas prior eTRE research has predominantly focused on leveraging the food-entrainable oscillator to improve metabolic functioning, our primary goal was to use eTRE to improve sleep. Specifically, we sought to explore if eTRE could be used to advance the timing of sleep. As a secondary outcome we examined if eTRE increased the amount of sleep (total sleep time [TST]).

METHODS

Participants

From February 2021 to October 2021, community-based adults were recruited via local advertisements on the NYU Shanghai campus and referrals from the broader community. Participants were included in the study if they (1) self-reported late sleep timing (ie, difficulties falling asleep before 1 AM) and (2) were fluent in English (ie, did not require translation services to engage in the study). Exclusion criteria included (1) currently active shift workers, (2) history of cardiometabolic health issues (eg, diabetes, cardiovascular disease), or (3) history of a diagnosed eating disorder.

The online inquiry form was completed by 21 individuals (**Figure 1**), 6 of whom were not eligible for this study. The remaining 15 individuals completed screening, met criteria, and were consented to participate in the study during the screening interview. This study was approved by the Institutional Review Board at NYU Shanghai and was registered at http://www.ChiCTR.org.cn.

Procedures

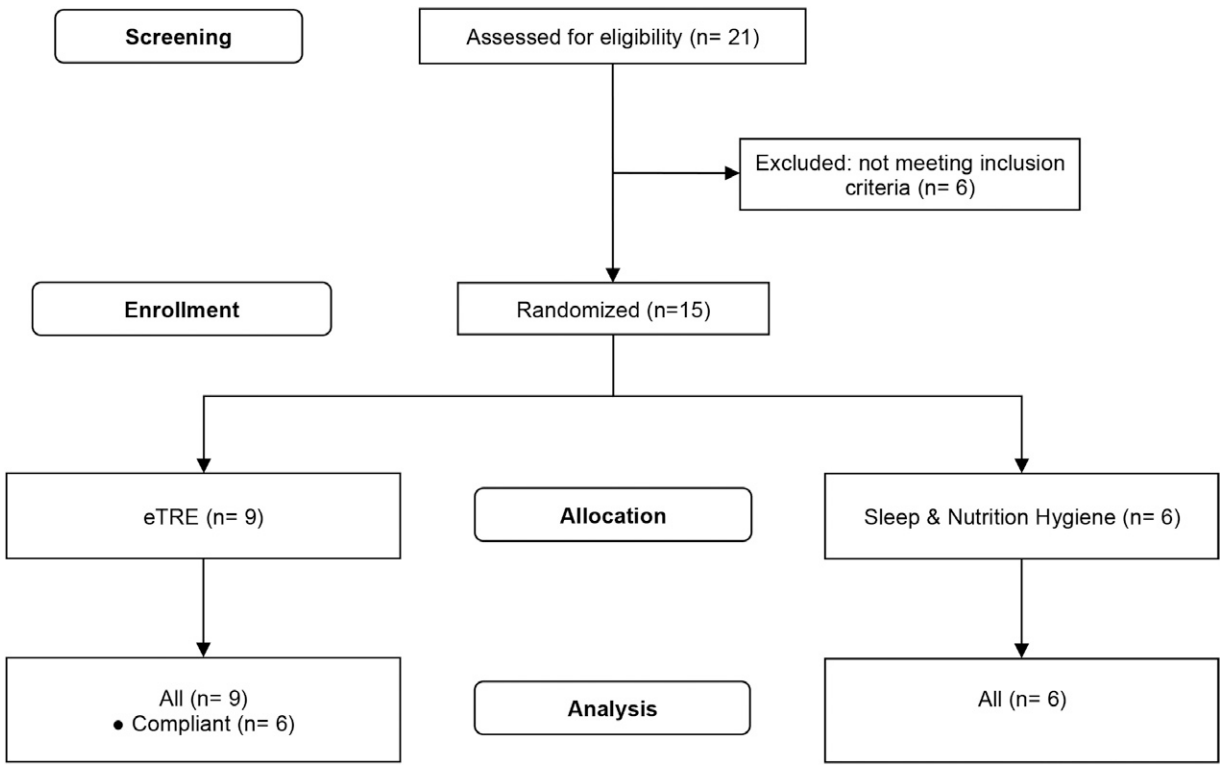
Study design

This study (**Figure 2**) was a randomized controlled trial design with 2 parallel groups comparing eTRE with a sleep and nutrition hygiene control treatment. Participants were randomized using block randomization (block size = 6).

Screening

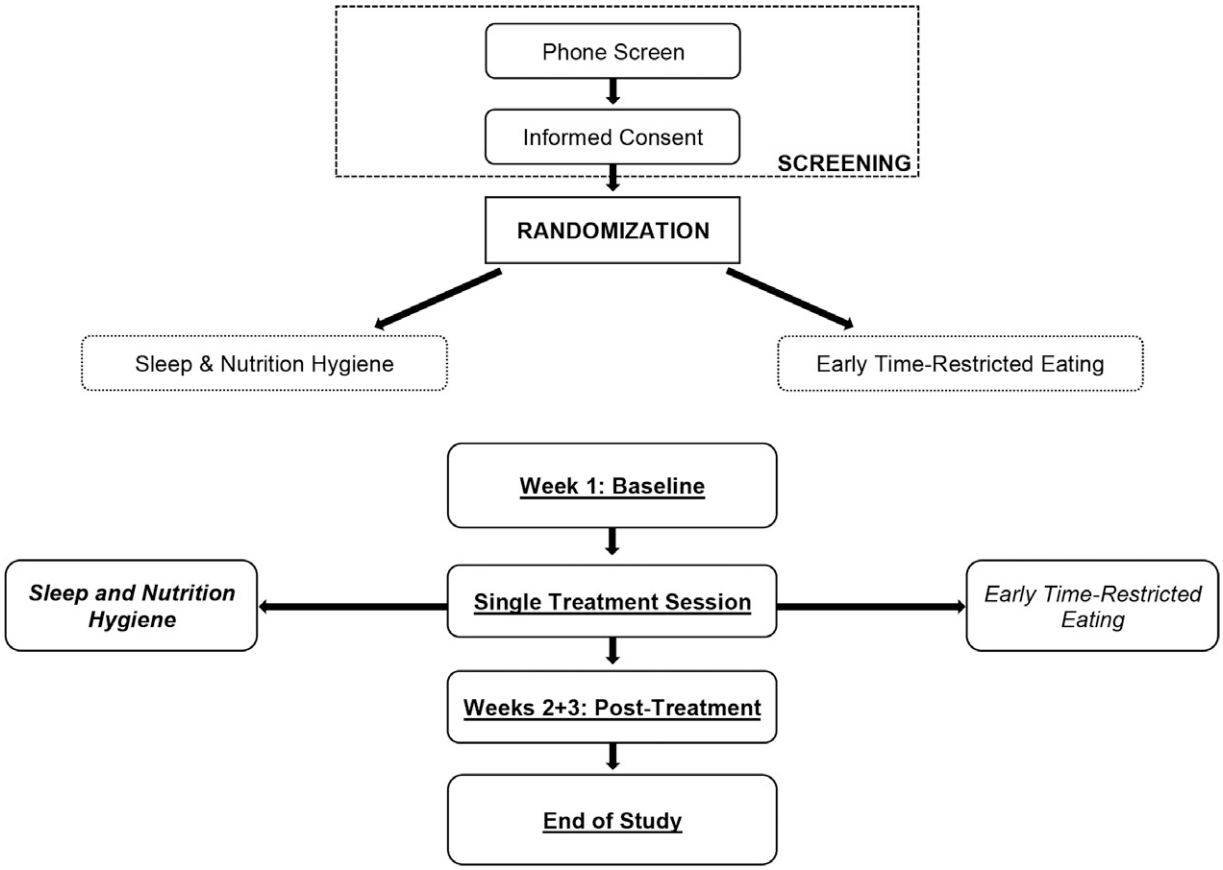
Individuals who were interested in participating initially completed a brief online questionnaire that included the basic inclusion/exclusion criteria and contact information. Individuals who met initial eligibility were then invited to conduct a phone interview with a sleep specialist/licensed psychologist to confirm eligibility using a brief clinical interview, cardiovascular health screening tool,[14] and the Eating Disorder Examination questionnaire (EDE 6.0[15]). Individuals with low risk on both questionnaires (ie, a negative history of 1 or more cardiometabolic health issues, 2 or more risk factors for cardiometabolic disease, or an EDE total < 1.27) and met inclusion/exclusion criteria following the clinical interview were randomized to either the active treatment or placebo condition.

Figure 1—CONSORT diagram.



Flowchart of participants through the trial. Three individuals allocated to receive eTRE did not comply with the study protocol. CONSORT = Consolidated Standards of Reporting Trials, eTRE = early time-restricted eating.

Figure 2—Study design.



Flowchart of participants through the trial.

Treatment overview

The treatment phase of the study included a baseline appointment and one 30-minute video session, the content of which varied between the 2 arms of the study (eTRE or sleep and nutrition hygiene). At the baseline appointment, participants completed web-based self-reported questionnaires administered via Qualtrics (Qualtrics, Provo, UT), reviewed instructions for wearing the Readiband V sleep and activity monitor (Fatigue Science, Inc, Vancouver, BC, Canada), were taught how to complete the sleep and nutrition diary, and scheduled their 30-minute intervention session. All participants wore a Readiband and tracked their sleep and nutrition (ie, the first and last intake of food or beverage excluding water) daily for a total of 3 weeks (1 week baseline, 2 weeks posttreatment). After 3 weeks of sleep and nutrition monitoring, participants completed the poststudy questionnaires and returned the Readibands.

Measures

Phone screen

Prospective participants were asked questions about their age, sleep timing, pregnancy, work schedule, history of and risk for cardiovascular health issues (AHA/ACSM [American Heart Association/American College of Sports Medicine] Health/Fitness Facility Preparticipation Screening Questionnaire), and history of and risk for an eating disorder (EDE 6.0). The AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire is a 32-item questionnaire that assesses the risk for cardiovascular health issues. It is split into 2 sections: (1) history of cardiometabolic diagnoses and symptoms and (2) current cardiovascular risk factors. Potential participants were excluded if they endorsed ≥ 1 item on section 1 and/or endorsed ≥ 2 items on section 2.

The EDE 6.0 is a valid and reliable 28-item questionnaire that assesses the risk for an eating disorder.[16] The EDE 6.0 has high internal consistency (Cronbach's α coefficient is 0.95) and high discriminative validity (area under the receiver operating characteristic curve [AUC] of 0.96). A cutoff score > 1.27 was used to determine risk for an eating disorder.[16,17]

Self-report measures

Participants completed self-report measures assessing sleep quality, daytime sleepiness, mood, and anxiety during the baseline week and at the end of the study.

The Pittsburg Sleep Quality Index (PSQI) is a widely used 19-item questionnaire that assesses sleep quality, sleep latency,

sleep duration, sleep efficiency, sleep disturbances, sleep medication use, and daytime energy. The PSQI has good internal consistency (Cronbach's α = 0.70–0.83), with higher scores (> 5) indicating poor sleep quality.[18]

The Epworth Sleepiness Scale (ESS) was used to assess excessive daytime sleepiness. It is one of the most commonly used self-report questionnaires and has shown to have good internal consistency (Cronbach's α ranges from 0.73 to 0.86) and moderate concurrent validity with objective tests of sleepiness.[19]

Mood was assessed using the 9-item Patient Health Questionnaire (PHQ-9), a 9-item depression measure that assesses depressive symptoms over the past 2 weeks. The PHQ-9 reports excellent internal consistency (Cronbach's α = 0.89).[20]

Anxiety was assessed using the 7-item Generalized Anxiety Disorder (GAD-7). The GAD-7 is a 7-item questionnaire that assesses anxious symptoms and reports excellent internal consistency (Cronbach's α = 0.92).[21]

Sleep diary

Prospective sleep patterns were recorded using a daily sleep diary based on the Consensus Sleep Diary.[22] The Consensus Sleep Diary is the gold-standard self-reported prospective measure of sleep and requires participants to answer the following questions upon awakening to start their day: bedtime, lights out, sleep-onset latency, number of awakenings, wake after sleep onset, wake time, rise time. Based on these values, additional aspects of sleep were calculated including sleep-onset time, midsleep phase (MSP), TST, time in bed, and sleep efficiency.

To assess for fasting duration, the sleep diary also included daily prompts for the first intake of food or beverage (excluding water) and the last intake of food or beverage (excluding water).

Wrist activity monitor

Readiband V5 wrist activity monitors were used to objectively measure movement, which can be used to impute sleep patterns. This device uses a proprietary algorithm to impute sleep and wake and performs comparably to research-grade actigraphy (ie, Philips Respironics Actiwatch 2[23]). For this study, analyses of Readiband V5 data focused on sleep-onset time, MSP, wake time, and TST.

Treatment conditions

Early time-restricted eating

The eTRE intervention consisted of one 30-minute session conducted on synchronous video by a licensed clinical psychologist. This session included a novel strategy for advancing sleep timing in which participants were instructed to adhere to a water-only fast for ≥ 16 hours between last food intake and first intake of food anchored to the desired rise time (eg, fasting from 4 PM until 8 AM) and sleep and nutrition hygiene (ie, 2-process model of sleep and wake, normal sleep architecture, sleep hygiene). Participants were instructed to adhere to this eTRE protocol for 2 weeks (14 days) after attending the virtual session.

Sleep and nutrition hygiene

Participants randomized to the control condition also received one 30-minute session conducted on synchronous video by a licensed clinical psychologist. The control group received information related to the 2-process model of sleep and wake, normal sleep architecture, sleep hygiene (eg, maintain regular sleep schedule, don't exercise too close to bedtime), and nutrition hygiene (eg, don't eat within 2 hours of bedtime, refrain from caffeine 6–8 hours prior to bedtime).

Data analysis

Linear mixed-effects modeling was used to calculate primary outcome measures using SAS version 9.4 PROC MIXED (SAS Institute, Cary, NC). Changes in actigraphy- and sleep diary–derived sleep-onset time, MSP, and wake time were analyzed as primary outcome measures. Secondary outcomes included changes in actigraphy- and sleep diary–derived TST as well as changes in self-reported sleep (ESS, PSQI) and mood (PHQ-9, GAD-7). Pre- to post-treatment changes in questionnaire data were analyzed using 2-sided unpaired *t* tests or Mann-Whitney *U* tests for nonnormal data. Significance level was set at .05; 2-sided *P* values are reported on all tests.

We powered our sample size based on a prior report examining the impact of time-restricted eating on sleep that reported odds ratios of 7.5 (flying eastward from the United States to South Korea) and 16.2 (flying westward back to the United States) regarding symptoms of jet lag.[11] We conservatively, therefore, predicted a medium effect size of our intervention. As such, using G*Power 3.0 (Universität Kiel, Germany), we estimated that a sample size of 12 (6 eTRE, 6 control) was sufficient to detect a clinically significant improvement in sleep timing based on an effect size of 0.5, power of 0.8, and 2 measurements comparing actigraphy- and sleep log–derived MSP pre- and post-intervention.

RESULTS

Participant characteristics

A total of 15 participants (male = 4, female = 10, preferred not to disclose = 1) were randomized to receive eTRE (n = 9) or sleep and nutrition hygiene (n = 6). There were no statistically significant differences between the groups in terms of age, sex ratio, education, ethnicity, marital status, or body mass index (**Table 1**). The groups were also similar in their mood (GAD-7, PHQ-9) scores, with approximately half of the participants from each group endorsing mild symptoms of anxiety or depression (**Table 1**). Groups were similar in their summary sleep (ESS, PSQI; **Table 1**) and showed no statistically significant differences at baseline with regard to both sleep diary– derived and wrist activity monitor–derived sleep parameters (**Table 2**).

Data attrition and adherence

Among all participants, there were acceptable levels of missing data for sleep diary variables (3.49%) and wrist activity monitors (6.35%). Three participants, randomized to the eTRE group, did not adhere fully to the protocol. Two participants adhered to eTRE but did not attempt to sleep earlier as was in the instructions. Another participant's understanding of English was not as fluent as conveyed and did not fully understand the instructions. Additionally, 2 eTRE participants were given permission to not

Table 1—Baseline participant demographic characteristics for both eTRE and control groups.

	eTRE (n = 9)	Control (n = 6)	*P**
Age, mean (SD), y	29.6 (9.9)	22.0 (4.6)	.11
Female, n (%)	6 (67)	4 (67)	1.00
Bachelor's/graduate degree, n (%)	5 (56)	3 (50)	1.00
Ethnicity, n (%)			
East Asian	5 (56)	5 (83)	.65
South Asian	1 (11)	0	
White	2 (22)	0	
Latinx	1 (11)	0	
Mixed	0	1 (17)	
Single, n (%)	7 (78)	6 (100)	.49
BMI, mean (SD)	23.1 (5.1)	18.9 (1.4)	.04
	(n = 8)	**(n = 6)**	
ESS	8.8 (3.8)	7.2 (5.2)	.52
≥ 11, n (%)	3 (37)	2 (33)	1.00
PSQI	8.5 (3.0)	7.2 (4.1)	.49
≥ 5, n (%)	8 (100)	5 (83)	.43
GAD-7	4.0 (2.9)	4.3 (5.4)	.88
≥ 10, n (%)	0 (0)	1 (17)	.43
PHQ-9	4.8 (4.0)	4.2 (5.3)	.82
≥ 5, n (%)	5 (63)	2 (33)	.59

*Difference between groups tested with unpaired *t* tests for age, BMI, ESS, PSQI, GAD-7, and PHQ-9, and with Fisher's exact test 2-sided probability for Female, Bachelor's/graduate degree, Ethnicity, and Single. BMI = body mass index, ESS = Epworth Sleepiness Scale, eTRE = early time-restricted eating, GAD-7 = 7-item Generalized Anxiety Disorder, PHQ-9 = 9-item Patient Health Questionnaire.

adhere to the eTRE protocol on preselected nights due to the conditions of the coronavirus disease 2019 (COVID-19) pandemic. The first participant went to bed later on 2 nights for regularly scheduled video calls with family. The other participant stayed up later to attend and present at international conferences via video calls. Given the small sample size, we conducted 2 sets of analyses based on all participant data and compliant-only data.

Primary outcome: sleep onset

Relative to the control group, the self-reported timing of sleep onset in the eTRE group moved 34.5 ± 15.8 minutes earlier in all participants and 56.1 ± 18.1 minutes earlier in compliant participants (**Table 3**). Similarly robust differences were observed in sleep-onset timing in wrist activity monitor data, with sleep timing moving 52.3 ± 17.9 minutes earlier in all participants and 66.5 ± 18.7 minutes earlier in compliant participants (**Table 3**).

Primary outcome: midsleep phase

Relative to the control group, the self-reported timing of sleep midpoint in the eTRE group moved 11.5 ± 5.5 minutes earlier in all participants and 19.5 ± 6.3 minutes earlier in compliant participants (**Table 4**). Similar differences were observed in MSP in wrist activity monitor data, with sleep timing moving 15.3 ± 5.7 minutes earlier in all participants and 21.9 ± 6.5 minutes earlier in compliant participants (**Table 4**).

Primary outcome: wake time

Relative to the control group, the self-reported timing of wake in the eTRE group moved 42.2 ± 20.0 minutes earlier in compliant participants; the 26.6 ± 17.1–minute shift to an earlier wake time in all participants was not significant (**Table 5**). Similar differences were observed in the timing of wake in wrist activity monitor data, with wake timing moving 39.3 ± 19.3 minutes earlier in compliant participants; the 30.0 ± 17.4 minutes earlier in all participants was not significant (**Table 5**).

Secondary outcome: total sleep time

Relative to the control group, there were no significant differences in TST per either self-report or wrist activity monitor (**Table 6**).

DISCUSSION

As compared with an education control, a single 30-minute session on eTRE elicited an advance of sleep timing by approximately 1 hour in late sleepers. The advance in sleep timing was evident in both self-reported (log) and objective (activity monitor) modalities and encompassed parallel shifts in the timing of sleep onset, sleep offset, and sleep midpoint.

We noted a non–statistically significant increase in TST as measured by both actigraphy (19.4 minutes) and sleep diaries

Table 2—Sleep characteristics.

	Wrist Activity Monitor				Sleep Diary			
	eTRE		Control		eTRE		Control	
	Baseline	Treatment	Baseline	Treatment	Baseline	Treatment	Baseline	Treatment
TST (hours)								
Compliant only	6.86 (0.77)	7.12 (0.80)			7.09 (0.61)	7.55 (0.63)		
All participant	6.85 (0.81)	7.07 (0.74)	6.43 (0.79)	6.43 (1.04)	7.13 (0.63)	7.55 (0.63)	6.41 (0.98)	6.71 (1.51)
SON (time)								
Compliant only	1:12 (71.9 min)	0:24 (57.7 min)			1:14 (43.7 min)	0:16 (48.5 min)		
All participant	1:02 (65.5 min)	0:29 (52.3 min)	1:47 (28.1 min)	2:09 (32.3 min)	1:02 (38.8 min)	0:26 (44.8 min)	2:03 (35.4 min)	2:00 (52.6 min)
WT (time)								
Compliant only	8:32 (51.9 min)	8:04 (48.2 min)			8:24 (36.2 min)	7:56 (42.6 min)		
All participants	8:24 (54.8 min)	8:07 (47.3 min)	8:39 (55.1 min)	8:59 (64.3 min)	8:19 (43.8 min)	8:07 (45.7 min)	8:36 (63.1 min)	8:48 (64.4 min)
MSP (time)								
Compliant only	4:52 (58.7 min)	4:14 (46.7 min)			4:40 (45.1 min)	3:58 (47.0 min)		
All participants	4:39 (54.7 min)	4:18 (45.5 min)	5:09 (39.3 min)	5:34 (40.3 min)	4:29 (44.4 min)	4:07 (47.4 min)	5:16 (47.4 min)	5:21 (40.8 min)

Baseline and treatment sleep characteristics as determined by objective (wrist activity monitor) and self-report (sleep diary) measures for both eTRE and control groups. Data are shown as mean (SD). eTRE = early time-restricted eating, MSP = midsleep phase, SON = sleep onset, TST = total sleep time, WT = wake time.

Table 3—Sleep onset.

	eTRE Change			Control Change			Difference in Change		
	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI
Sleep diary									
Compliant only	−58.3 (12.9) min	<.0001	−83.6, –32.9 min	−2.2 (12.7) min	.86	−27.2, 22.8 min	−56.1 (18.1) min	.002	−91.7, –20.5 min
All participants	−36.6 (10.1) min	.0003	−56.4, –16.8 min	−2.1 (12.2) min	.86	−26.4, 21.9 min	−34.5 (15.8) min	.03	−65.6, –3.3 min
Activity monitor									
Compliant only	−43.1 (13.1) min	.001	−68.9, –17.4 min	23.4 (13.4) min	.08	−3.0, 49.7 min	−66.5 (18.7) min	.001	−103.4, –29.6 min
All participants	−28.9 (11.1) min	.01	−50.8, –7.1 min	23.4 (14.1) min	.10	−4.3, 51.1 min	−52.3 (17.9) min	.004	−87.6, –17.0 min

Baseline and posttreatment means estimated from the linear mixed-effects models for eTRE and control groups for sleep diary– and activity monitor–derived sleep onset. CI = confidence interval, eTRE = early time-restricted eating.

Table 4—Midsleep phase.

	eTRE Change			Control Change			Difference in Change		
	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI
Sleep diary									
Compliant only	−17.0 (4.5) min	.0002	−25.8, –8.2 min	2.6 (4.4) min	.56	−6.1, 11.2 min	−19.5 (6.3) min	.002	−31.9, –7.2 min
All participants	−9.0 (3.5) min	.01	−15.8, –2.1 min	2.6 (4.2) min	.55	−5.8, 10.9 min	−11.5 (5.5) min	.04	−22.3, –0.7 min
Activity monitor									
Compliant only	−13.3 (4.5) min	.004	−22.2, –4.3 min	8.6 (4.7) min	.07	−0.5, 17.8 min	−21.9 (6.5) min	.001	−34.7, –9.1 min
All participants	−6.6 (3.5) min	.06	−13.6, 0.4 min	8.6 (4.5) min	.06	−0.2, 17.5 min	−15.3 (5.7) min	.01	−26.6, –4.0 min

Baseline and posttreatment means estimated from the linear mixed-effects models for eTRE and control groups for sleep diary– and activity monitor–derived midsleep phase. CI = confidence interval, eTRE = early time-restricted eating.

Table 5—Wake time.

	eTRE Change			Control Change			Difference in Change		
	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI
Sleep diary									
Compliant only	−28.0 (14.3) min	.05	−56.1, 0.00 min	14.1 (14.0) min	.31	−13.4, 41.6 min	−42.2 (20.0) min	.04	−81.5, −2.9 min
All participants	−12.5 (10.9) min	.25	−33.9, 8.9 min	14.2 (13.2) min	.28	−11.7, 40.1 min	−26.6 (17.1) min	.12	−60.2, 7.0 min
Activity monitor									
Compliant only	−22.6 (13.5) min	.10	−49.2, 4.0 min	16.7 (13.8) min	.23	−10.5, 43.8 min	−39.3 (19.3) min	.04	−77.3, −1.3 min
All participants	−13.3 (10.8) min	.22	−34.5, 7.9 min	16.7 (13.6) min	.22	−10.2, 43.8 min	−30.0 (17.4) min	.09	−64.2, 4.3 min

Baseline and posttreatment means estimated from the linear mixed-effects models for eTRE and control groups for sleep diary– and activity monitor–derived wake time. CI = confidence interval, eTRE = early time-restricted eating.

Table 6—Total sleep time.

	eTRE Change			Control Change			Difference in Change		
	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI	Estimate (SE)	*P*	95% CI
Sleep diary									
Compliant only	28.5 (13.9) min	.04	1.2, 55.8 min	17.4 (13.7) min	.20	−9.5, 44.3 min	11.2 (19.5) min	.57	−27.2, 49.5 min
All participants	25.9 (10.8) min	.02	4.6, 47.2 min	17.3 (13.1) min	.19	−8.5, 43.2 min	8.6 (17.0) min	.61	−24.9, 42.0 min
Activity monitor									
Compliant only	16.5 (13.1) min	.21	−9.4, 42.3 min	−3.0 (13.4) min	.82	−29.4, 23.4 min	19.4 (18.7) min	.30	−17.5, 56.3 min
All participants	12.9 (10.6) min	.23	−8.1, 33.8 min	−3.0 (13.5) min	.83	−29.5, 23.6 min	15.9 (17.2) min	.36	−18.0, 49.7 min

Baseline and posttreatment means estimated from the linear mixed-effects models for eTRE and control groups for sleep diary– and activity monitor–derived total sleep time. CI = confidence interval, eTRE = early time-restricted eating.

(11.2 minutes). Given the high degree of night-to-night variability in TST, especially among late sleepers,[24] we were not powered to detect these differences. Post hoc power analyses indicated that we would have needed 53 participants in each group to detect such a difference. If these gains were to hold true, they would be clinically significant and on par with increases in TST generated by 6 to 8 weeks of cognitive behavioral treatment for insomnia, the gold-standard treatment for insomnia.[25]

There were several limitations. As noted, the small sample size did not allow for detection of clinically meaningful changes in TST. We also had one-third of the eTRE group failing to adhere to the protocol. As mentioned previously, these were seemingly unrelated to the protocol itself (2 failed to understand that they needed to follow the earlier sleep timing in addition to eTRE; 1 presented with significant language difficulties), although a larger sample may reveal otherwise. Next, early meal timing can be challenging to adhere to due to cultural, social, and work requirements. Additionally, late sleepers may have difficulties eating earlier due to a delay in the natural timing of their hunger/appetite. The sample was also more socioeconomically advantaged compared with the general public and thus our results may not be generalizable to the general public. Finally, we did not have long-term follow-up, so do not know whether the shift to an earlier time would be stable over an extended time.

Overall, we found that a brief, single-session intervention to teach about eTRE was sufficient to advance the sleep of late sleepers by 1 hour. The present study was the first to trial eTRE as a sleep intervention in a randomized controlled trial. It shows intriguing potential as a novel strategy for both advancing sleep timing as well as increasing sleep duration in late sleepers. Future research is required to validate this method on larger, more representative samples, elucidate the mechanistic aspects of this technique, and explore the potential of eTRE in related paradigms of circadian misalignment, such as shift work, jetlag, and circadian rhythm sleep-wake disorders.

ABBREVIATIONS

EDE, Eating Disorder Examination questionnaire
eTRE, early time-restricted eating
GAD-7, 7-item Generalized Anxiety Disorder
MSP, midsleep phase
PHQ-9, 9-item Patient Health Questionnaire
PSQI, Pittsburg Sleep Quality Index
TST, total sleep time

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